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(54) Wideband optical link

(57) A wideband optical link, e.g. for 8 TV channels or a block of stereo audio channels uses a highly linear VCOO (1) to which the multiplex inputsignal is applied. The VCO output is applied to a mixer (2) where it is mixed with the signal from an oscillator (3). The mixer output goes to a filter (4) which passes the desired mixer's sideband, in this case the lower sideband, and this, via amplifiers (5) and limiter (6) controls the laser (7) whose output is applied to an optical fibre. Thus the highly linear VCO enables a laser of relatively poor linearity to be used.

At the receiver (Fig. 2) the signal from an optical receiver (10) goes via a filter (11) to another mixer (12), whose output is filtered (14) to pass the desired mixer sideband. This then goes via a differential demodulator (15-16-17) to an output filter (18), the output of which is the receiver's output.

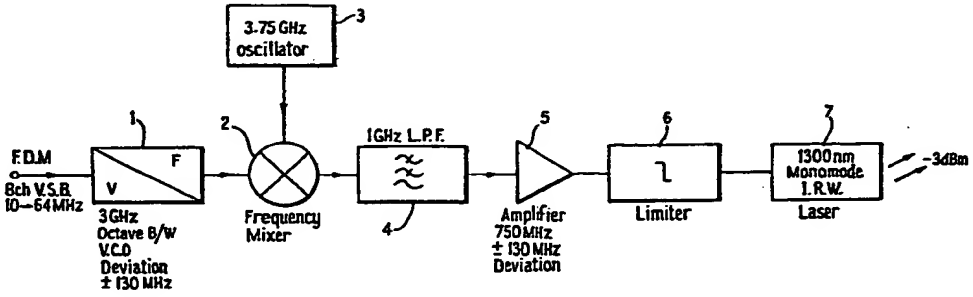

FIG. 1 PFM FIBRE OPTIC Tx

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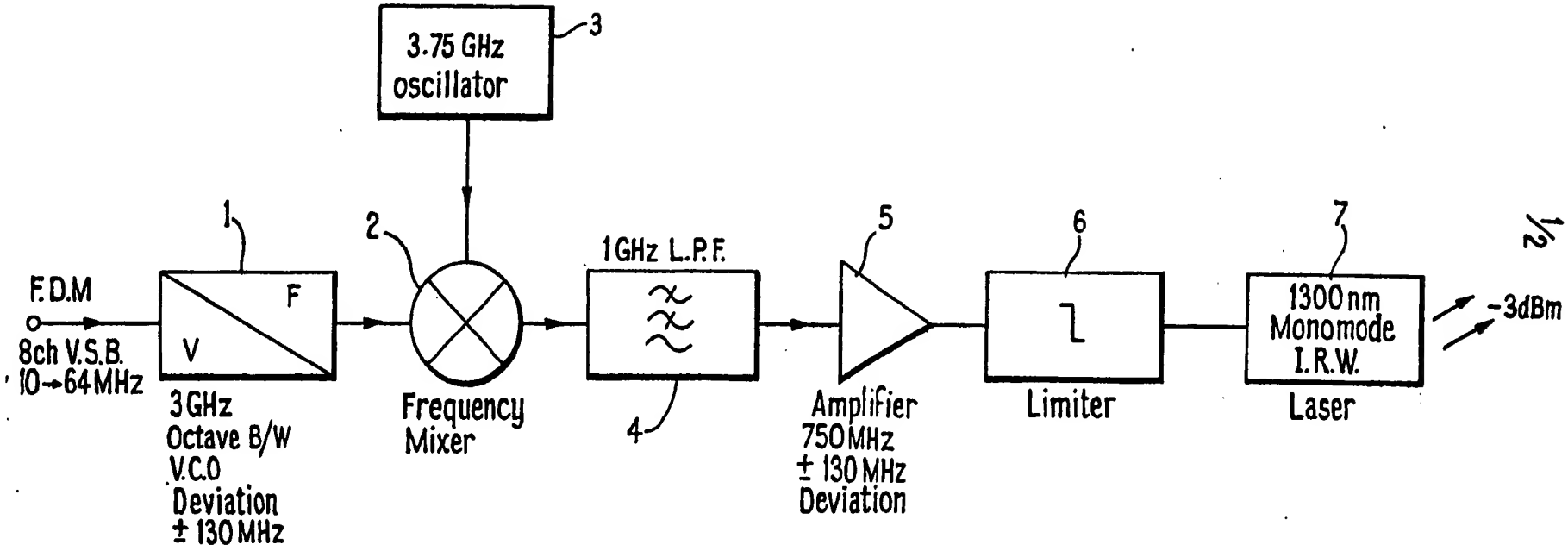

FIG. 1 PFM FIBRE OPTIC Tx

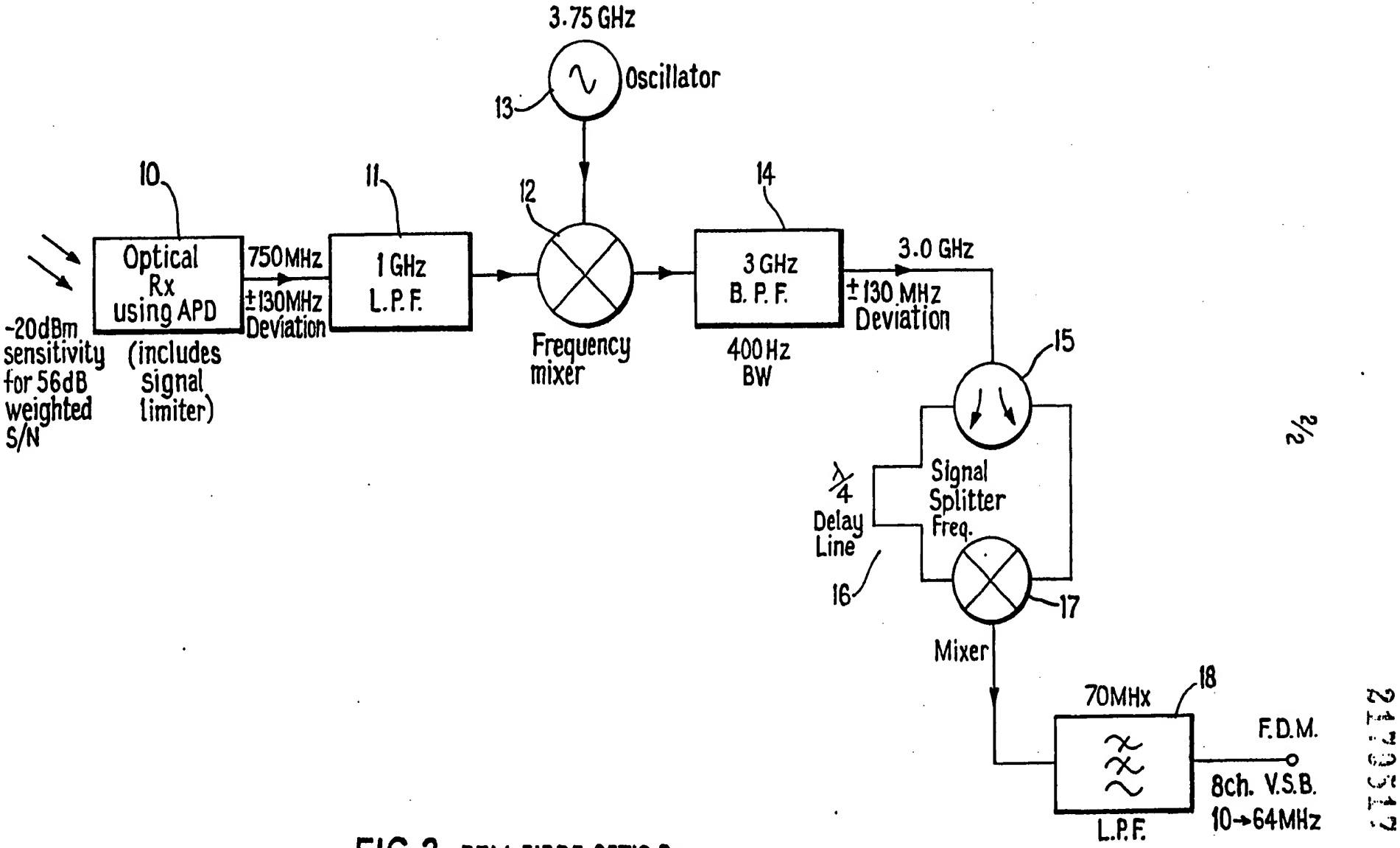

FIG. 2 PFM FIBRE OPTIC Rx

SPECIFICATION

Wideband optical link

This invention relates to wideband optical links, i.e. links in which the transmission medium is light sent via optical fibre or via free space.

Wideband links are needed for, among other applications, multiplexed television channels and also for conveying stereo audio channels. With a reasonable number, e.g. eight, of VSB (Vestrigral Side Band) modulated television channels in a multiplex, or an equivalent number of stereo audio channels, it is at best very difficult to obtain an adequate signal-noise ratio using direct intensity modulation of a laser.

An object of this invention is to enable an optical link to convey such multiplexed channels wherein the above disadvantages are reduced or even eliminated.

According to the invention, there is provided a wideband optical link for conveying multi-channel information, in which the information is conveyed using pulse frequency modulation with the information to be conveyed modulated on to the desired carrier via a highly linear voltage controlled oscillator, the result of the modulation being applied to a laser from which the modulated light beam is sent over the transmission medium of the link.

Such a system has the advantage that the laser used does not need to have highly linear characteristics. While the voltage controlled oscillator (VCO) does need to be highly linear this is not a serious difficulty since highly linear VCO's are commercially available.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which Fig. 1 is a PFM fibre optic transmitter and Fig. 2 is a PFM fibre optic receiver, both for a system embodying the invention.

The optical link, in this case an optical fibre link, will be described as used for eight video (television) channels. The system takes as its input a block of eight VSB - FDM (Vestigial Side Band - Pulse Frequency Modulation) signals with 8 MHz channel spacing. In one example the frequencies of the VSB carriers are as below:

Channel 1 —— 10 MHz		Channel 5 —— 42 MHz	
Channel 2 —— 18 MHz		Channel 6 —— 50 MHz	
Channel 3 —— 26 MHz		Channel 7 —— 58 MHz	
Channel 4 —— 34 MHz		Channel 8 —— 66 MHz	

Such a multiplex of frequencies may be obtained in known manner for combining the outputs of VSB modulators and/or off-air frequency converters, or by down-converting from an existing multiplex used on an existing co-axial VSB system.

The incoming multiplexed signal is applied to an ultra-linear 3 GHz VCO 1 with a ± 130 MHz deviation. The modulated output from the VCO is applied to a frequency mixer 2, where it is mixed with the output of a 3.75 GHz oscillator 3. The output of the mixer 2 therefore includes a 750 MHz carrier conveying the input multiplex and having the same deviation as the VCO. This output is applied to a 1 GHz low pass filter 4 to give as its output the modulated 750 MHz carrier, which is applied via an amplifier 5 and a limiter 6 to a laser 7. The laser is, in the present example, a 1300nm IRW laser, and the carrier applied to it switches the laser 7 on and off at a mean optical power of —3dBm. The laser output enters the optical fibre (not shown) by which the signal reaches the receiver.

The receiver, Fig. 2, has a sensitivity estimated to be —20dBm for 56dB weighted video signal/noise ratio for eight channel capability.

The incoming light signal from the fibre is applied to an optical receiver 10, which uses as its light-receiving device an avalanche photodiode (APD). Such a receiver is better for the present application than one using a PIN-FET, since in the present application, unlike in digital systems the higher leakage currents of a germanium APD are not significant. The optical receiver 10, in the present case, includes a series of limiting amplifiers, followed by a 1 GHz low pass filter 11, which removes any high-order harmonics which fall in the 3GHz region.

The signal which leaves the filter 11 has to be up-converted into the 3GHz region before demodulation, to obtain the required degree of linearity in frequency to voltage conversion. Hence the filtered signal is applied to one input of a frequency mixer 12 whose other input is from a 3.75 GHz oscillator 13. The output of this mixer is applied to a 3 GHz band-pass filter 14, which has a bandwidth of 400MHz. Thus the output from this filter is a 3.0 GHz signal, with a deviation of ± 130 MHz.

The output of the filter 14 is applied to a demodulator formed by a signal splitter 15, quarter-wave delay line 16 and frequency mixer 17. These items together form a delay line discriminator, and its output is applied to a 70 MHz low pass filter 18. Hence the original VSB multiplex is removed at the receiver. This eight channel multiplex is then either demodulated using commercially available demodulators or up-converters to form part of a 30 channel VSB multiplex which is compatible with a co-axial type of VSB system.

We have mentioned above that a PFM link embodying the invention can also be used to transmit a seteo radio muliplex. This is assumed to be in the 88-108 MHz band, and is down-converted to the 5-25 MHz region. The multiplex then modulates to ultra linear. VCO as described with reference to Fig. 1. the multiplex then is then recovered from the receiver, Fig. 2, in the manner described with reference to Fig. 2. The multiplex is then up-converted to the 88-108 MHz band, and received using a standard FM broadcast band tuner/radio.

In the frequency mixers 2 and 12, the desired output is the difference between the frequencies of the signals to be mixed; if the desired output is the sum of those two frequencies, the successive filters' pass characteristics would differ appropriately from those of the filters 4 and 14.

CLAIMS

1. A wideband optical link for conveying multi-channel information, in which the information is conveyed using pulse frequency modulation with the

information to be conveyed modulated on to the desired carrier via a highly linear voltage controlled oscillator, the result of the modulation being applied to a laser from which the modulated light beam is sent over the transmission medium of the link.

2. A link as claimed in claim 1, in which the output from the voltage-controlled oscillator is applied to a frequency mixer to the other input of which is applied the output of an oscillator, in which the output of the mixer is applied to a filter which passes the desired side-band of the mixer's output, and in which the filter output is applied via amplifier/limiting circuitry to the said laser.

3. A link as claimed in claim 1 or 2, in which at a receiver the light in the medium is applied to an optical receiver whose output is applied to a further mixer whose other input is a signal from an oscillator, in which the further mixer output is applied to a filter which passes the desired side-band of the mixer's output, and in which said further mixer's output is applied via demodulation means to a filter whose output is the signal originally applied to the voltage-controlled oscillator.

4. A transmitter station for a wideband optical link via which information is conveyed using pulse frequency modulation, in which the information as received is a multiplex of a number of information bearing channels which is modulated by a highly linear voltage controlled oscillator whose output is applied to one input of a frequency mixer, in which a signal from an oscillator is applied to the other input of the mixer, whose output is applied to a filter, in which the filter passes the desired sideband of the mixer output, which desired sideband is applied via amplifier/limiting circuitry to a laser, the modulated output of the laser being applied to an outgoing optical fibre.

5. A receiver station for a wideband optical link via which information is conveyed using pulse frequency modulation, in which a modulated light beam carrying said information as received over an incoming optical fibre is applied to a light responsive diode in an optical receiver, in which the optical receiver's output is applied via a filter to an input of a frequency mixer to the other input of which the signal from an oscillator is applied, in which a further filter to which the output of the mixer is applied passes the desired mixer side-band and in which said desired sideband is applied from said further filter to a differential demodulator whose output, via yet a further filter is the wanted information.

6. A transmitter for a wideband optical fibre link, substantially as described with reference to Fig. 1 of the accompanying drawings.

7. A receiver for a wideband optical fibre link, substantially as described with reference to Fig. 2 of the accompanying drawings.

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